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Indian Devil Tree, *Alstonia scholaris* (L.) R.Br. (Sub-family Rauvolfioideae: Family Apocynaceae): Pollination ecology and seed dispersal versus human health

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ABSTRACT

Alstonia scholaris is an evergreen winter blooming hermaphroditic tree species. The floral traits such as anthesis during dusk and early dark hours, creamy white or greenish white color, pungent odor and low volume of nectar indicate that it is adapted for moth-pollination. Accordingly, it is pollinated by moths and also by bees, flies and butterflies. The tree is self-compatible, self-pollinating and facultative autogamous. Fruits are 2-follicled, many-seeded, autochorous and anemochorous. Dry season is ideal and quite effective for seed dispersal. In *A. scholaris,* the pungent odor of flowers cause mild breathing problems and sleeping difficulty under cool weather only in areas where this tree is planted massively under urban afforestation-cum-beautification programs. This breathing problem is amplified by profuse flowering and production of huge number of flowers daily by each tree. The pollen is not airborne due to cool weather and placement of stamens inside the corolla tube but slight horizontal orientation of flowers, pollen collection activity by bees and pollen release from withered flowers allow liberation of dry pollen into the air. During dry season, huge loads of comose seeds and heavy load of bioparticulate material produced by decomposition of empty follicles travel through the air and cause allergy problems in sensitive people. Therefore, the study indicates that massive plantations of *A. scholaris* in cities cause a health concern for city residents but scattered planting of a small number of trees of this species is a viable option to avoid health problems in sensitive urban people.

Keywords: *Alstonia scholaris*, winter bloomer, entomophily, autochory, anemochory, human health.

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1. INTRODUCTION

Apocynaceae comprises of 5,100 species placed in five subfamilies, Apocynoideae, Asclepiadoideae, Periplocoideae, Rauvolfioideae and Secanomoideae (Nazar et al. 2013; Endress et al. 2014). In India, this family represents approximately 30 genera with more than 60 species (Jones and Luchsinger 1987). The genus *Alstonia* with 45 species occurs in Africa, Central America, Southeast Asia, Polynesia and Australia; it is named after the distinguished botanist, Prof. C. Alston at Edinburgh University (Orwa et al. 2009). In this genus, only *A. scholaris* is widely reported throughout its distribution and in areas of its cultivation as an ornamental tree, because of its harmful effects on human health. The species name applies to its wood which is used for making school boards and slates in Myanmar (Orwa et al. 2009) but anonymous authors posted on the internet that the species name also refers to the fragrance of flowers that enabled the scholars to gain concentration and new ideas when they sat underneath the tree. In the Theravada Buddhism, it is said that this tree is the source for Lord Buddha for achieving enlightenment. But, tribal people in the Western Ghats believe that it is a devil tree. It is native of tropical and subtropical Africa but it is now distributed in India, China, southeast Asia and Australia (Pratap et al. 2013). Anonymous authors and newspapers reported on the internet that *A. scholaris* wood is used for making pencils, coffins, packing boxes, blackboards, household utensils and trenchers. Its leaves are awarded as a symbol of simplicity and connection with the nature to outgoing graduates, post-graduates and research students by Chancellor at Visva-Bharati University. This tradition was initiated by Bengali Nobel Laureate Gurudeb Rabindranath Tagore, the founder of that University. *A. scholaris* is widely planted under afforestation programs and as an avenue or ornamental tree in urban centers in India. But, it is reported that this tree is inducing respiratory illness and allergy problems across the country by print and electronic media; in consequence, trees of this species were cut down in many urban centers without conducting any scientific study to know whether this species is really a nuisance or menace in areas where it is planted or raised for beautification or for greenery development. With this background, the present study was made to describe floral biology, pollination, pollinators and seed dispersal, and all these aspects were evaluated as to their role in the occurrence of human health issues as reported in the media.

2. MATERIALS AND METHODS

Alstonia scholaris raised as massive plantations along roadside and on road dividers in areas of VUDA Park, Hanumanthawaka Junction to Simhachalam road, Arilova and Rushikonda under urban afforestation drive in Visakhapatnam, Andhra Pradesh, India, were selected for the study during September-2019 to February 2020 and October 2020 to March 2021. Phenology, flowering season, flower morphology, floral biology, foraging activity, pollinators, fruit development and seed dispersal were examined in this tree species. Nectar volume was measured and the duration of stigma receptivity was recording using the procedures described in Dafni et al. (2005). One hundred and fifty flowers from twenty inflorescences were tagged and followed for five weeks to record the duration of fruit development, fruit dehiscence and seed dispersal. Flowers visitors were recorded by making observations at the plants from morning to late evening. The forage sought and forage collection behavior were carefully observed to record the pollination role of individual species of flower visitors. Further, the importance of floral odor, pollen and seed dispersal in causing health concerns in urban residents was evaluated by field observations and by personal interviews with people residing at the areas of plantations of this tree species.

3. OBSERVATIONS

Flowering and floral biology: *A. scholaris* is a fast growing medium to large evergreen tree with dense crown. The bark is greyish-brown, corky, lenticellate and peels off as small paper flakes. The branches arise from the trunk at the same height and are oriented in whorls. Leaves are petiolate, simple, leathery, narrow elliptic to oblanceolate with cuneate base and rounded apex; they are arranged in whorls, each with 5-9 leaves but mostly with 7 in number (Figure 1b). Leaf fall and flushing is simultaneous throughout the year. Flowering period varies from tree to tree at the same or different sites. Flowering occurs from November to December but certain individuals extended flowering up to February (Figure 1a). Inflorescence is a much-branched pedunculate terminal panicle or compound compact umbel consisting of about 500 flowers. Mature buds open during 1700-2000 h. The flowers are pedicellate, small, creamy white or greenish white, tubular, actinomorphic, bisexual and produce pungent odor (Figure 1c). The calyx is cupular with five green ovate ciliate lobes. The corolla is salvar-shaped, tube villous inside and its throat has a ring of downwardly pointed hairs; the throat is extended into 5 cuneate, oblong pubescent twisted spreading lobes with rounded apex. The stamens are 5 and inserted near the corolla throat and connate with the tube of the corolla; the anthers are creamy white, introrse, basifixed and dehisce soon after anthesis by longitudinal slits. The pollen grains are tricolporate, prolate spheroidal, and 33 μm in diameter with granulate surface. The ovary has two free carpels, each with many ovules arranged on parietal placentation. The styles are two, filiform and hollow but gradually fused to form a bilobed conical wet stigma which becomes receptive soon after anthesis and

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remains so until noon of the following day. The nectar secretion is initiated from mature bud stage and it amounted to 2.7 ± 0.46 µl per flower.

Figure 1. *Alstonia scholaris*: a. Tree in flowering phase, b. Leaves, c. Flowers, d. Rock bee, *Apis dorsata*, e. Syrphid fly, *Helophilus* sp., e. Nymphalid butterfly *Euploea core*, f. & g. Hesperiid butterflies – f. *Borbo cinnara*, g. *Iambrix salsala*, h. Crambid moth, *Palpita* sp.

Pollinators: The flowers were foraged by bees, flies, butterflies and moths. The diurnal hawk moths, *Macroglossum gyrans, Cephonodes hylas* made visits to the flowers as soon as they are open and continued their activity until sunset, and again visited the same flowers on the following day from sunrise time and continued for about 2 hours. Another moth commonly called Jasmine moth or Pearl moth, *Palpita vitrealis* (Figure 1h) also visited the flowers after sunset (1800 h) and continued its visits until 2000 h. All other insects visited the flowers during day time, bees from 0730 to 1530/1600 h, flies from 0900-1600 h and butterflies from 0745/0800 to 1500/1600 h. Of these, bees foraged for pollen and nectar, flies for pollen and butterflies and moths for nectar. Among bees, *Apis dorsata* (Figure 1d) was relatively more successful in collecting nectar when compared to the other bee species but all of them were collected pollen with great ease as the anthers are placed inside near the throat of the corolla tube. The fly, *Helophilus* (Figure 1e) with its short proboscis could only collect pollen. All butterflies (Figure 1e-g) and moths had proboscis longer than the length of corolla tube and hence they easily accessed the corolla base for nectar collection. All categories of insects contacted the stamens and stigma while collecting the forage facilitating the occurrence of either or self- or cross-pollination. Since individual trees produce numerous inflorescences and each with numerous flowers, the bees and flies foraged mostly on the same tree facilitating mostly the occurrence autogamy and/or geitonogamy. Butterflies and moths collected nectar at random from different inflorescences of the same tree and moved to nearby conspecific flowering trees in quest of nectar collection; this foraging behavior facilitated the occurrence of mostly xenogamy followed by geitonogamy. Among all these insects, only moths visited the just open flowers for nectar while all other insects visited the flowers on the following day. Bees made 40%, flies 9%, butterflies 29% and moths 22% of total visits. Although bees made highest percentage of foraging visits, their visits mostly ended in self-pollination (Table 1).

Table 1. Flower-foragers, their foraging schedule and percentage of total flower visits on *Alstonia scholaris*

Flower-foragers	Foraging schedule (h)	Total flower-visits (%)
Bees		
Apis dorsata F.	0730-1700	15
Apis cerana F.	0730-1700	14
Ceratina sp.	0730-1700	11
Flies		
Helophilus sp.	0900-1600	9
Butterflies		
Euploea core Cramer	0800-1500	6
Hypolimnas misippus L.	0800-1500	6
Tirumala limniace Cramer	0800-1530	7

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Tirumala septentrionis Butler	0745-1530	7
Borbo cinnara Wallace	0800-1600	6
Iambrix salsala Moore	0800-1600	6
Moths		
Macroglossum gyrans Walker	1700-1800 & 0530-0730	4
Cephonodes hylas L.	1700-1800 & 0530-0730	5
Palpita vitrealis Rossi	1800-2000	13

Percentage of flower visits for each insect species is based on total flower visits made by all insect species.

The flowers were used as food by the House Sparrow, *Passer domesticus* (Figure 2a,b). This bird species simply plucks the flowers and sucks the nectar from the corolla base. Since the tree produces massive flowering, the flower removal activity by this bird is highly negligible and hence has negligible role in affecting the success of sexual reproduction. The flowers wither and fall down under the crown of the tree (Figure 2c).

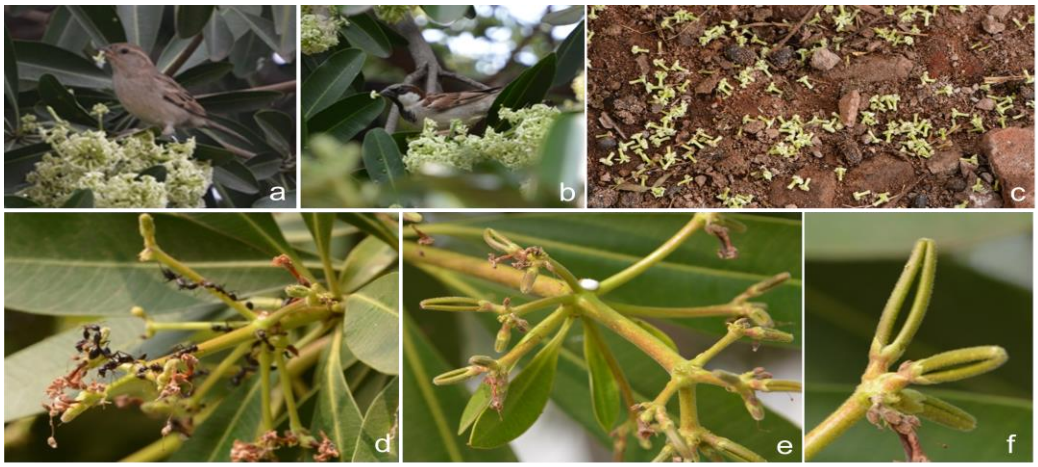

Figure 2. *Alstonia scholaris*: a. House Sparrow, *Passer domesticus* (female), b. *Passer domesticus* (male), c. Fallen flowers, d. *Camponotus* sp., e. & f. Growing fruits (follicles).

Figure 3. *Alstonia scholaris*: a. Fruiting phase, b. 2-follicled fruit, c. Dehisced follicles, d. Dehisced follicles with seeds tipped with coma still attached.

Fruiting and seed dispersal: Fruits mature within 3 weeks (Figure 2e,f, 3a). During fruit development, *Camponotus* sp. (Figure 2d) collects secretions from the fruiting branches and their presence throughout the day appeared to be a defense for the tree against frugivores. The fruiting rate is 58% in open-pollinations. Fruit is distinctly 2-follicled (Figure 3b). The follicles are linear, pendulous, many seeded, green initially and brown later. Each follicle dehisces longitudinally into two halves to release seeds (Figure 3c,d). The fully formed and mature seeds are very small and compressed with a fringe of long brown silky hairs at each end and adapted for wind dispersal. Follicles that mature before February dehisce late due to cool ambient conditions while those that mature after February dehisce quickly due to onset of warm ambient conditions. Accordingly, seed dispersal efficiency by wind is very low for

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the follicles that dehisce before February and very high for the follicles that dehisce after February. Since the trees used for the study are in urban area, there is almost no possibility for seed germination due to covering of land with roads and buildings.

Impact of floral pungent odor, airborne pollen and dispersal of comose seeds of *A. scholaris* on human health: The massive plantation drive using *A. scholaris* as an important ornamental-cum-avenue tree was taken up in the study locations and this tree was planted in continuous rows on a large scale. During flowering season, the flowering is very profuse and the flower density increased due to production of numerous flowers in numerous compound compact umbels at tree level. As the flowers produce pungent odor to attract their pollinating insects, especially moths during dusk and early dark hours, this pungent odor is further strengthened due to production of anthesis of numerous flowers and planting of these trees in continuous rows. The cool ambient conditions during early evening and in the night during the flowering season causes the ambient air to become thick due to concentrated pungent odor released by the flowers. As a consequence, the people standing under or relaxing in the surroundings of trees experience a sense of mild uncomfortable condition characterized by shortness of breath which is technically called "dyspnea" because of difficulty in getting air fully into the lungs. Further, the people living in the vicinity of trees of this species planted massively experience sleeplessness or sleeping difficulty during its flowering season, especially during peak flowering season which lasts for about 2-3 weeks only.

The flowers with stamens placed inside the corolla tube do not have wide scope to release pollen grains into the ambient air. But, dry pollen may come out of the corolla tube due to slight horizontal orientation of flowers and its load in the air depends on the pollen production rate by individual flowers and availability of pollen after its collection by bee pollinators. Since this species is a winter bloomer, the prevailing low ambient temperature largely keeps the pollen in semi-dry state and minimizes its release into the air. Insect foragers, especially bees could make the pollen airborne while collecting pollen with their vibrating wings; they could also drop pollen into the air while in flight mode. Further, the wilting or withering flowers may release pollen into the air if pollen still remains in them. All these means of pollen discharge from the flowers are further subjected to the varying wind speeds during daytime. Therefore, the flowers have low possibility to discharge huge pollen load into the ambient air during winter season.

Fruit follicles mature mostly from February onwards when dry conditions begin to emerge. Since they dehisce while on the parental trees, the comose seeds disperse easily under windy conditions. In the study locations, moderate to high wind speeds occur during February to early April. In this situation, the seeds fly away and during travel, the silky hairs may break forming fragments that also fly in the air. People exposed to the airborne fragments of comose hairs of seeds may experience allergy problems, especially asthmatics. The allergy problems include sneezing, eye redness, skin rashes and respiratory discomfort. Since this tree species is planted under massive plantation drive, people living in its localities experience the allergy problems resulting from seed dispersal. Further, the empty follicles gradually decompose and release particulate or granular powder which travels easily through the air; people exposed to this powder may also develop certain allergy problems.

4. DISCUSSION

Pollination ecology: *Alstonia scholaris* is an evergreen hermaphroditic tree species. It produces branches in whorls forming a unique form of crown with aesthetic appeal. It also produces leaves in whorls which give a special appearance in leaf arrangement pattern. Its evergreen appearance owes to its simultaneous occurrence of leaf fall and flushing side by side. A couple of studies from West Bengal reported that *A. scholaris* is airborne and it is recorded during June-July (Mandal et al. 2008) and September-November (Hussain et al. 2014). Chauhan and Nisha (2018) reported that *A. scholaris* blooms during winter season and also extends into dry season in case of certain individuals. In the study locations, *A. scholaris* blooms characteristically during winter season but individual trees display asynchronous flowering. This tree species produces massive flowering which is displayed by numerous much-branched terminal compound compact umbels and each umbel producing numerous flowers. With this prolific flowering, the creamy white to greenish white flowers with pungent odor enhance their attraction to the intended pollinating insects.

Chauhan and Nisha (2018) reported that *A. scholaris* flowers are open during late evening hours. But, in the study locations, the mature buds of *A. scholaris* begin to open before sunset and continue until late evening hours. Mondal et al. (1998) reported that *A. scholaris* is insect-pollinated but insects that pollinate its flowers were not documented by them. Pratap et al. (2013) reported that *A. scholaris* is pollinated by butterflies and bees. Chauhan and Nisha (2018) reported that *A. scholaris* is pollinated by honey bees, wild bees, wasps, ants, butterflies and moths. Of these insects, bees forage during 0400-1900 h, wasps during 1100-1700 h, ants during 0500-1900 h, butterflies during 1200-2000 h and moths during 1900-0400 h. In the study locations, it is observed that *A. scholaris* is pollinated by bees, flies, butterflies and moths. Of these, moths displayed two different foraging schedules; *Macroglossum gyrans* and *Cephonodes hylas* commonly known as diurnal hawk moths are crepuscular and visit the flowers immediately after anthesis and

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continue their forage collection until sunset only, and again visit the flowers on the follow day from sunrise time for about 2 hours while *Palpita vitrealis* commonly known Jasmine or Pearl Moth visit the flowers after sunset and until 2000 h only. Bees, flies and butterflies are diurnally active with varying time schedules but all ceased their forage collection activity by 1600 h. The foraging schedules followed by these diurnal insects coincide well with low winter temperatures during early morning and early evening. Further, bees, wasps and butterflies visit the flowers during the period between sunrise and sunset. But, Chauhan and Nisha (2018) reported that bees visit the flowers long before sunrise and continue their forage collection after sunset, and butterflies visit the flowers for more than 2 hours after sunset. The foraging schedules of bees and butterflies reported by these authors are totally incorrect and need re-verification. In the study locations, it is found that *A. scholaris* produces nectar in a small quantity which is as low as 3 µl per flower. This study disagrees with the report by Chauhan and Nisha (2018) that *A. scholaris* flowers produce nectar continuously for 2 consecutive days with 132 µl on the day of anthesis and 155 µl by the noon of the following day and thereafter the nectar secretion declines and becomes dilute**.** Since *A. scholaris* produces small pungent odor flowers with low amount of nectar, it is basically adapted for insect-pollination and accordingly it is observed to be entomophilous. Moths utilize fresh nectar from just open mature buds while all other insects utilize the left over nectar in visited flowers and also in unvisited flowers on the following day. In *A. scholaris*, the timing of anthesis, pungent odor production, creamy white to greenish white flower color and low volume of nectar indicate that it is typically moth-pollinated but it is additionally pollinated by bees, flies and butterflies during day-time on the following day. Among all insect species recorded, moths and butterflies effect mostly cross-pollination due to their frequent inter-tree movement for nectar collection while bees and flies effect mostly for self-pollination due to their limited inter-tree movement.

Chauhan and Nisha (2018) reported that *A. scholaris* does not breed through spontaneous autogamy as the flowers that were bagged by them did not result in fruit set but they reported that this species breeds through geitonogamy with 80% fruit set and through xenogamy with 20% fruit set. They also documented that nearly 70% fruit set occurs in open-pollinated flowers indicating that fruit set occurs mostly from geitonogamy. Despite very high fruit set rates in geitonogamy and open-pollinations in this species, these authors reported it to be self-incompatible which is incorrect. The present study shows that *A. scholaris* flowers are homogamous and facilitate self- and cross-pollinations through entomophily. Fruit set (nearly 60%) is very high in open-pollinations indicating that *A. scholaris* is self-compatible and facultative autogamous. Mondal et al. (1998) reported that *A. scholaris* produces more than 5,000 pollen grains per flower. Since each flower of *A. scholaris* produces many ovules, the pollen-ovule ratio indicates that it is facultative autogamy (Cruden 1977). Therefore, *A. scholaris* is typically facultative autogamous, a mixed mating system that provides opportunities to receive potential benefits resulting from self- and cross-pollinations (Cruden and Lyon 2019).

Fruit dehiscence and seed dispersal: In *A. scholaris*, fruits mature rapidly without any pause in their growth and development. Fruit is 2-follicled and each follicle is many-seeded. The follicles dehisce to disperse the comose seeds which are either instantaneously or subsequently dispersed by the prevailing wind indicating that the tree is both autochorous and anemochorous. The dispersal efficiency of seeds depends on the time of maturation of follicles; the ones that mature before the commencement of of dry season dehisce late while the ones that mature at the commencement of or during dry season dehisce quickly and hence their dispersal distance varies depending on the ambient temperature and relative humidity. The study found that dry season is ideal and effective for seed dispersal in *A. scholaris*. Since the study localities are essential part of urban ecosystem, the possibilities for seed germination and subsequent seedling establishment are rare due to covering of most of the urban land area with roads and buildings.

Floral pungent odor, airborne pollen and dispersal of comose seeds of *A. scholaris* versus human health: Massive plantations of *A. scholaris* are creating certain health concerns among urban residents. Its flowers produce strong pungent odor to attract its pollinating insects, especially moths during dusk and early dark hours. This pungent odor is strengthened and amplified by the production of numerous flowers in numerous compound compact umbels at tree level; this odor is further amplified by the flowering of numerous trees planted in continuous long rows. Since it is a winter bloomer, the cool ambient conditions during early evening and in the night cause the ambient air to become thick due to high concentrations of pungent odor released by the flowers. In this situation, people in the surroundings of this tree during flowering season experience mild breathing problem, sleeplessness or sleeping difficulty, especially during peak phase of flowering which lasts for about 2-3 weeks only.

Mondal et al. (2008) reported that A. scholaris pollen is airborne and it contributes to 0.29% of total air spora during June-July period in Calcutta City. Basak et al. (2017) reported that A. scholaris pollen contributes to 1% of total yearly contribution of airborne pollen in the air of Santiniketan. Hussain et al. (2014) reported that A. scholaris pollen contributes to 0.28% and 0.3% of total airborne pollen in Durgapur and Siniketan, respectively during September-November in West Bengal. Further, these authors also

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stated that its pollen could be a significant aeroallergen for sensitive people. These reports indicate that airborne A. scholaris pollen is highly negligible and hence is not a health concern for humans. In the present study, it is observed A. scholaris flowers have limited possibility to pump out pollen into the ambient air because the stamens are placed within the corolla tube. However, dry pollen may come out of the corolla tube due to slight horizontal orientation of flowers and pollen availability after its collection by bee pollinators. Since it is a winter bloomer, pollen is in semi-dry state due to low ambient temperature and hence pollen release into the air is minimized. Insect foragers, especially bees could make the pollen to become airborne during pollen collection by vibrating their wings and during flight mode by dropping pollen. The pollen could also become airborne upon wilting or withering of flowers but its release is subject to the pollen availability in those flowers but the pollen in these flowers, if present, is usually not viable and inactive. The airborne pollen travel by all these means again is a function of wind. Therefore, *A. scholaris* pollen has limited scope to become airborne during winter season to cause allergic problems in sensitive people.

In *A. scholaris*, fruit follicles dehisce to release comose seeds which are easily dispersed by wind. The silky hairs present at the ends of seeds break and the resulting fragments travel through the air by wind during dry season. As fruit set rate is very high and each follicle produces many seeds, their silky hair fragments during seed dispersal process accumulate in the atmosphere. In this situation, people exposed to this air may experience allergy problems such as sneezing, eye redness, skin rashes and respiratory discomfort. Further, the empty follicles also charge the air with bio-particles or powder by their decomposition during dry season and people exposed to the air charged with its bio-particles may also develop certain allergic symptoms. The seed dispersal process and decomposition process of empty follicles are indirectly responsible for allergic problems in humans. Therefore, massive plantation of *A. scholaris* under urban afforestation program for greenery development is causing allergy problems which are encountered by local residents.

Ecological services of *A. scholaris* plantations: Pratap et al. (2013) stated that *A. scholaris* with their large branches provide favorable nesting sites for wild bees. Balachandra et al. (2014) documented that *A. scholaris* is an important host for the migratory honey bee, *Apis dorsata* for its colony formation in the Western Ghats. But, here, *A. scholaris* is not used by *A. dorsata* or wild bees as their nesting sites. Shafiq et al. (2011) mentioned that *A. scholaris* could be used as a bioindicator of cadmium and lead in polluted environments. Here, *A. scholaris* trees have been planted mostly in residential areas and hence its use as biomarkers of air pollutants cannot be explained. Wang et al. (2014) documented that *A. scholaris* produces pentacyclic triterpenoid allelochemicals in their leaves. The triterpenoids present in fallen leaves that form litter in the soil inhibit seed germination, radicle growth and photosystem II in *Bidens pilosa*, a weed species of Asteraceae. Since *A. scholaris* is a producer of allelochemicals, it could inhibit other tree species which are planted under the program of urban greenery development.

5. CONCLUSIONS

Alstonia scholaris is an evergreen winter blooming hermaphroditic tree species. The floral traits such as anthesis during dusk and early dark hours, creamy white or greenish white color, pungent odor and small amount of nectar indicate moth pollination syndrome. The study indicates that it is moth-pollinated after anthesis and by bees, flies and butterflies on the next day. High fruit and seed set rates in open-pollinations mediated by insect pollinators indicate that the tree is self-compatible, self-pollinating and facultative autogamous. Fruits are 2-follicled, many-seeded, autochorous and anemochorous. Dry season is ideal and quite effective for seed dispersal.

A. scholaris with flowers producing pungent odor cause mild breathing problem and sleeping difficulty under cool weather only when this tree is planted massively under urban afforestation-cum-beautification programs. This health problem is amplified by profuse flowering and production of huge number of flowers daily by each tree. The pollen is not airborne but pollen dispersal into the air is remotely possible due to slight horizontal orientation of flowers, pollen collection by bees and pollen release from withered flowers. During summer season, huge loads of comose seeds and heavy load of bioparticulate material produced by decomposition of empty follicles of *A. scholaris* plantations travel through the air and cause allergy problems in sensitive people. Therefore, the study indicates that massive plantations of *A. scholaris* in cities cause a health concern for urban residents but planting it in a scattered form is a viable option to avoid health problems in sensitive urban people.

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Authors' contributions

All authors contributed equally.

Ethical approval

The ethical guidelines for plants & plant materials are followed in the study for species collection & identification.

Conflict of Interest

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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